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(NASA-CR-178947) NOSI EXPERIMENT SUPPORT  
Final Report, 1 Jan. 1980 - 31 Jul. 1986  
(New Mexico Inst. of Mining and Technology)  
4 p

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Final Report on Contract NAS8-33817

"NOSI EXPERIMENT SUPPORT"

Covering the period from

1 January 1980

To

31 July 1986

New Mexico Institute of Mining and Technology  
Socorro, New Mexico

Principal Investigator  
Marx Brook (505) 835 5611

October 2, 1986

### Introduction.

The research on this program started about one year before the contract was awarded to New Mexico Tech. The Principal Investigator, Dr. Marx Brook, joined with Dr. Bernard Vonnegut to interpret optical lightning data which would be forthcoming from the NOSL experiment planned for the Space Shuttle. Thus the original contract was titled "NOSL Experiment Support". As part of a preliminary study it was planned to use an optical sensor on an airplane flying above thunderstorms. An optical lightning detector was constructed at New Mexico Tech and flown, along with Vinton Cameras and a Fairchild Line Scan Spectrometer, on a U-2 during the summer of 1979. The flight was successful. The U-2 lightning data was obtained in daylight, and was supplemented with ground truth data taken at Langmuir Laboratory. The original funding for the contract was \$10,000.

The NASA co-principal investigator was Mr. O.H. Vaughan, ES83, MSFC.

### Objectives and Requirements of the Contract.

1. Help develop and participate in simulations as required to establish experiment operating procedures and science training for the astronauts who will operate the NOSL equipment during the STS-2 NOSL experiment on the Space Shuttle.

2. Be present in the JSC Mission Control Center to assist in directing the experiment and answer questions.

3. Assist in the preparation of the flight data analysis and be responsible for sections in the preliminary and final evaluation/experiment operation report.

4. Additional requirements involved travel to MSFC and JSC for coordination with the experiment manager and participation in the NOSL crew training exercises and simulations.

### Funding and Modifications of the Contract.

On 9/3/80, the contract was amended with the addition of \$3500 in funds, primarily for additional travel to MSFC, JSC, and ARC.

On 2/23/81, the contract was again modified to provide NOSL support for the reflight of the NOSL experiment on STS-4 and STS-6. Requirements were essentially the same as for the earlier STS-2 experiment. The funding was augmented by an additional \$15,000 for these activities.

On 7/20/81, the contract was again modified to allow Gov't furnished property, in the amount of \$19,000, to be added to the contract. The equipment was a Sangamo 'Sabre 80' tape recorder for use in analyzing the magnetic tapes acquired during the U-2 aircraft overflights of thunderstorms. By this time New Mexico Tech had furnished a slow antenna electric field-change instrument to Mr. John Arveson of Ames to be mounted, along with the optical sensor and cameras, in the Q bay of the U-2 aircraft.

Modification number 4 to the contract was made on 3/29/82 with the addition of \$15,000 to continue the analysis of the NOSL data, and to provide support to the Lightning Mapper program administered by Dr. Hugh Christian.

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Modification number 5 was made on 3/1/83 with the addition of \$20,000 to the contract.

The no cost extensions to the contract were provided on 2/29/84, 2/28/85, 5/31/85, 10/1/85, and 3/31/86. The funded extensions were granted primarily for performing the data analysis of the U-2 tapes, and for travel to MSFC to report the results during the annual program review conference. The final contract activity occurred during the period preceding the 1986 Huntsville field program with the U-2 based at Wallops Island. The principal investigator spent one full week at MSFC repairing and calibrating the slow antenna and the optical wide-angle detector (WAD) prior to its deployment on the U-2 instrument pallette. The contract terminated on 7/31/86. A total of \$63,500 was involved in the contract covering the total period from April 1 1980 to July 31 1986.

Contract Results.

All of the requirements regarding astronaut training, presence at JSC during the Space Shuttle flights, and preparation of experimental data and results were accomplished as outlined in the contract requirements. Further activities related to the NASA Lightning Mapper Program, in which we participated. This part of the program involved construction and preparation of the instruments for flight on the U-2 aircraft and the analysis of the magnetic tapes from those flights. Several trips to the Ames Research Center were made in preparation for thunderstorm overflights which covered areas of New Mexico, South Dakota, Alabama, Georgia, and Oklahoma. By far the major activity on the contract over the last three years has been the analysis of data and the preparation of papers for publication. As referred to earlier, the last activity before the end of the contract was done in Huntsville preparing the slow antenna and the optical WAD instruments for the 1986 summer field program.

Details of the research results of the program are given in a series of publications in refereed scientific journals and are listed in the next section. In this section we summarize the program results as follows:

a. Lightning flash development as seen from the Space Shuttle was a new experience-we were amazed to see how a lightning flash can continue to discharge cells over a huge area (at least 60x40 km) and funnel the charge down a single channel to earth. We estimated that this flash lowered somewhere in the vicinity of 500 coulombs of charge to earth.

b. From the initial optical measurements on a U-2, we conclude that, although the sample of lightning discharges is small, the measurements indicate that probably enough optical signal is present for the detection of most lightning flashes from a geosynchronous satellite.

c. The rise-time of the optical signals which emerge through the cloud top is far slower than the electric field risetimes. Optical risetimes associated with return strokes average about 100 to 200 microseconds; many are as long as 350-500 microseconds. This result appears to show that, whereas electric radiation fields depend upon the rate of rise of current, the optical rate of rise is determined by the rate of growth of the elongating luminous channels as well as by multipath scattering in the cloud.

d. Some optical signals reveal a lightning fine-structure which parallels the electric field changes associated with leader-return stroke pairs. At present, we are not able to explain why some flashes exhibit this fine structure while others do not. The delineation of the optical leader strokes requires resolution of about 100 microseconds or better, a value barely possible with the slow tape speed used on the U-2 flights (in order to increase the data taking time). If it can be shown that the leader is a regularly recognizable feature of the above-cloud optical radiation from ground strokes, its presence could form the basis for distinguishing between cloud-to-cloud and cloud-to-ground flashes.

Additional results are detailed in the publications listed below.

List of Publications and reports resulting from this research.

Brook, M., R. Tennis, C. Rhodes, Paul Krehbiel, O.H. Vaughn, and B. Vonnegut, Simultaneous Observations of Lightning Radiations from Above and Below Clouds, Geophys. Res. Let., 7, 267-270, 1979.

Davis, M.H., Marx Brook, Hugh Christian, Brian G. Heikes, Richard E. Orville, Chung G. Park, Raymond G. Roble, and Bernard Vonnegut, Some Scientific Objectives of a Satellite-Borne Lightning Mapper, Bulletin of the American Meteorological Society, 64, 114-119, 1983.

Christian, H.J., R.L. Frost, P.H. Gillaspy, S.J. Goodman, O.H. Vaughan Jr., M. Brook, B. Vonnegut, and R.E. Orville, Observations of Optical Lightning Emissions from Above Thunderstorms Using U-2 Aircraft, Bulletin of the American Meteorological Society, 64, 120-123, 1983.

Vonnegut, B., O.H. Vaughan Jr., and Marx Brook, Photographs of Lightning from the Space Shuttle, Bulletin of the American Meteorological Society, 64, 150-151, 1983.

Brook, M., C. Rhodes, O.H. Vaughan Jr., R.E. Orville, and B. Vonnegut, Nighttime Observations of Thunderstorm Electrical Activity from a High Altitude Airplane, J. Geophys. Res., 90, 6111-6120, 1985.

Vonnegut, B., O.H. Vaughan Jr., M. Brook, and Paul Krehbiel, Mesoscale Observations of Lightning from the Space Shuttle, Bulletin of the American Meteorological Society, 66, 20-29, 1985.

Some of the above material appeared first in greater detail in NASA technical Memorandums TM 86455, TM 86451, and TM 82530.

In addition to the above refereed publications, 10 papers were presented at scientific meetings--primarily at the Fall Meeting of the American Geophysical Union in San Francisco.

One Master's degree thesis was supported on the project:  
"Some Properties of Lightning Radiation in the Frequency Range 30 to 3000 MHz", by C. T. Rhodes, New Mexico Tech, 1984.